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Target Acquisition and Analysis Training System: Effects on Combat Vehicle Identification (CFI) Performance of Number of Vehicles Trained, Training Frequency, and Soldier Trainability

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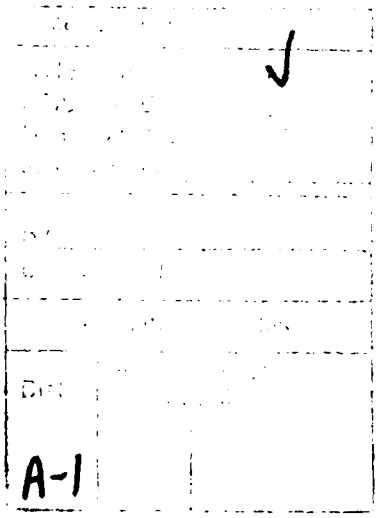

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Three groups composed of 27, 26, and 25 soldiers each, matched on GT scores, were given repeated training on varying numbers of vehicles taken from the Basic CVI Training Program (GTA 17-2-9). One group was trained on two modules of five vehicles each (10), a second on three modules (15) and a third on four modules (20). The training took place on each of three days. The training required, on the average, 25 minutes to train each module of five vehicles. The four-module group received four repetitions during during the three days (total of 6.7 training hours) while the 2- and 3-module groups received six repetitions (5 hours and 7.5 training hours respectively). An initial pretraining test was given, followed by posttraining tests administered at the completion of each training repetition. The tests consisted of having the soldiers identify projected slides of each vehicle. Three views (front, oblique, side) of each vehicle were randomly presented.

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19. ABSTRACT (continued):

Earlier research with the CVI program (Shope et al., in preparation) demonstrated a significant relationship between recognition and identification (R&I) performance and specific vehicle parts vocabulary. A test [the Verbal Cue Recognition (VCR) test used by Shope] was administered in this research before the pretraining test. Comparison of the VCR scores for these three groups showed a lack of balance; hence, a sample of 15 soldiers was drawn from each group so that those groups were now balanced (matched) on both GT and VCR test scores.

When 200 minutes of training time were allocated to learning 20 vehicles, the results indicated that two 50-minute training sessions teaching vehicles 1-10 followed by two 50-minute training sessions teaching vehicles 11-20 (total training time of 200 minutes) yielded a mean of 33.7 vehicle slides correctly identified, versus 29.7 slides for the group tested after receiving two 100-minute sessions teaching vehicles 1-20 (total time also 200 minutes). The same pattern existed when 300 and 400 minutes of training time were allocated.

The initial sample group of 78 soldiers was divided into "low" and "high" achievers based on their relative performance on the first posttraining test. In each of three vehicle groups, the mean percentage of slides identified by the "high" achievers on their first repetition was not reached by the "low" achievers until their fourth training repetition.

The report suggests the following:

- Although additional research is required to conclusively establish the effects of overlearning on retention of this type of material, training of no more than 10 different vehicles per training session is more effective than training that addresses more than 10 vehicles per session.

- Some soldiers have extreme difficulty learning to recognize and identify vehicles even after lengthy training. Consideration should be given to using a selective procedure, such as test scores following a single training session on the Basic CVI Training Program, to determine who should receive additional R&I training.

TARGET ACQUISITION AND ANALYSIS TRAINING SYSTEM: EFFECTS ON COMBAT VEHICLE IDENTIFICATION (CVI) PERFORMANCE OF NUMBER OF VEHICLES TRAINED, TRAINING FREQUENCY, AND SOLDIER TRAINABILITY

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INTRODUCTION

Background: Training Development in Vehicle Recognition

In 1980, the Target Acquisition and Analysis Training System (TAATS), a part of the research program at the Army Research Institute's Field Unit, Fort Hood, Texas, was established. The major objective of TAATS was to provide a framework within which to develop a series of interrelated target acquisition training programs. Five have been developed, tested and turned over to the Army. They are the Basic Combat Vehicle Identification (CVI) Training Program, the Basic Thermal Combat Vehicle Identification (TCVI) Training Program, The Advanced Combat Vehicle Identification Training Program, the Flash Card Program and The Combat Vehicle Identification Training Program for the Remotely Piloted Vehicle (RPV). Three of these programs--the CVI, TCVI, and the Flash Card program--have been adopted and issued by the Army as standard training for vehicle identification, GTA 17-2-9, GTA 17-2-10, and GTA 17-2-11, respectively. The Advanced CVI awaits funding. The RPV program was used to train operators during the Developmental Test (DT) II in June, 1982.

Military Challenge: Maximum Training Benefit in Minimum Training Time

Vehicle recognition and identification (R&I) is one of several skills soldiers must develop in order to pass a Skill Qualification Test (SQT). In many Combat Arms units as little as one hour per 6 month unit training cycle may be devoted to vehicle R&I. Hence, R&I proficiency must rely upon informal training in the soldier's common skills by the platoon sergeant or squad leader. Based on the Field Manual 21-2, "Soldier's Manual of Common Tasks, Skill Level 1," dated October, 1983, all soldiers in the Army must be able to correctly recognize 8 out of 10 vehicles as friend or threat; and identify 7 out of 10 by name and number of vehicle. These 10 vehicles are selected at random from a larger group of 30.

Research conducted at Fort Hood, Texas, June through August, 1982, assessed how well CVI material was retained. During this period soldiers received training on 10 vehicles on each of three successive days for a total of 30 vehicles (Heuckeroth, Smith, & Shope, in prep.). Results showed initial learning difficulty followed by a rapid decline during a three week period prior to re-testing with some recovery following retraining three and six weeks after the original training.

In summary, the military training environment for R&I is constrained by the limited time allotted, the difficulty with initial learning and the rapid decay of that knowledge.

Scope of This Research Report

This research represents one of a series of investigations on the topic of target acquisition done under the Target Acquisition and Analysis Training System work area. During the course of the work a number of relevant issues to training have been addressed. The reader of this report will find it necessary to be familiar with this background in order to fully understand this research. The following brief review will assist the casual reader who does not have the time or inclination to read more completely into the field.

Definition of Terms Recognition and Identification. The terms "recognition" and "identification" were found to have a number of meanings, depending on the source used. From the outset of the research in 1978, the terms were thought of as categories which required increasing amounts of information. Hence, recognition required a statement that a vehicle was a friend or a threat while identification required the additional information of the name or number of the vehicle.

As research progressed and data accumulated, analyses showed that recognition and identification are highly correlated when the training provided is sufficient to permit identification performance to reach modest levels. In one empirical effort, soldiers were asked after three training trials to specify the order in which they responded to a recognition/identification task. They were about equally divided; some processed the information about the vehicle as T-62, Soviet, threat while others reversed the order. These soldiers' performance scores were highly correlated for recognition and identification.

However, further examination of the utility of the recognition response brought out these considerations. Accurate assessment of a soldier's skill level by using his recognition responses leaves too much to chance in that the soldier has a 50-50 chance of making a correct response. A unit trainer does not have time to apply the arithmetic corrections to adjust for this. He, therefore, may have highly inaccurate information about his soldiers' skills. From a research perspective, the recognition response is further complicated by its dichotomous character which reduces variability and the range of scoring possibilities. For these reasons, the identification response was selected as the dependent variable in this and other research because it represented a more valid measure of whether a soldier actually knew a vehicle or not.

Finally, the objective of target identification for the TAATS working group was to reduce self-inflicted casualties in our Army as well as to increase the skill of the observer in more accurately assigning engagement priorities to targets and to select the correct ammunition for those engagements.

The definitions used throughout this work effort were adopted by the Proponent for Vehicle Recognition for the Army, Combined Arms Center, in 1986, as the official definitions.

Module Performance Generalization. The Basic Combat Vehicle Identification (CVI) Training Program (GTA-17-2-9) was designed and tested in 1979. It is a six module training program with a 7th module test. Each of the training modules was designed to stand alone as a training element with its own test. Modules have both NATO and WARSAW Pact vehicles selected by the Army community in 1979 as the core requirement for all combat arms soldiers. These 30 vehicles were distributed through the six modules so as to equalize difficulty. Comparisons of performance across modules resulted in no statistical differences among modules (Smith et al., 1980). This characteristic allows the researcher to use any number of the modules and be able to generalize about the factors affecting recognition and identification performance on the CVI training program as a whole.

Vehicle Presentation Characteristics.

Aspect Angle. The CVI program uses 2 vehicle views in the test for the 30 vehicles. The views are the frontal and a left or right oblique view. The frontal position of the vehicle (target aspect angle) was found to be significantly more difficult than the oblique views. Moreover, performance during individual module tests (which included a side view of each vehicle trained) indicated no performance differences to vehicles presented in a side or an oblique view (Haverland and Maxey 1978; Smith et al., 1980; Heuckeroth et al., in prep.). In research conducted with the CVI program it was noted that using only two views in the 30 vehicle test produced a conservative estimate of the soldier's knowledge; in subsequent research three views were used for testing.

Range. The CVI program is designed to simulate various ranges and optical powers. Ranges between 1000 and 3000 meters were found to have no effect on performance (Warnick & Kubala, 1979; Kottas et al., 1980; Smith et al., 1984). In another research effort, performance actually improved as range increased from 1200 meters to 3000 meters (Heuckeroth et al., in prep.). In subsequent research, range was generally not analyzed but for experimental control care was taken to distribute soldiers with important characteristics evenly across ranges. Moreover, research objectives in other research reduced sample sizes to an extent that range was not routinely analyzed.

Purpose of This Research Report

There were two major objectives of this research. The first was to examine performance changes as a function of whether groups are trained on 10, 15 or 20 combat vehicles per training session. The second was to examine whether all soldiers can be expected to benefit uniformly from repeated training. The focus of the research was on more effective utilization of the Army's Basic CVI Training Program (GTA 17-2-9). Hence, its modular construction (5 vehicles per module) dictated the number of vehicles used--10, 15, and 20.

METHOD

Personnel

A total of 90 military personnel, in pay grades of E2 to E6 were requested from three battalions of the 1st Cavalry Division, Fort Hood, Texas. From each unit, personnel were to be selected such that an equal number of soldiers from each of three GT categories, 110 or greater, 91 to 109, and 90 or below were included. Inspection of the roster before the research began showed that three-fifths of the soldiers had combat support or combat service support MOSs in the combat arms units. Research by Shope et al., in prep., reported that soldiers with non-armor MOSs were shown to be less familiar with vehicle part names used as identifying cues in training vehicle identification with the Combat Vehicle Identification Program. A test called the Verbal Cue Recognition Test (VCR) used by Shope in his research was found to be significantly correlated with identification performance.[1] Based on this finding and on the fact the troops in this research, although in armor units had non-armor MOSs, the VCR test was given before training.

Soldiers were initially assigned to one of three groups and given the VCR test and a CVI pretest appropriate to their group assignment which was also the posttest used following each training period.

In the three groups, 27 in group one, 26 in group two, and 25 in group three completed all training. After training was completed for all soldiers, Chi-Square analyses of the groups were done to insure that they did not differ significantly on GT and VCR (variables observed to have effected vehicle identification performance in the past research). The results showed groups were balanced on GT but not on VCR test scores. In order to compare groups, a subsample of soldiers matched on GT and VCR was drawn from each group. The result was 15 soldiers per group.

An ANOVA was then done to verify the balance. Table 1 shows means and standard deviations of GT and VCR scores for each matched group, together with results of the statistical analysis. Results of these analyses established that the matched groups are not significantly different in GT or VCR scores.

The identification test scores from the original groups of 27, 26, and 25 soldiers were also used in this report to examine performance within the groups.

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[1] A copy will be provided on request.

Table 1

Mean and Standard Deviation of GT and Verbal Cue Recognition (VCR) Scores for Each Matched Group (n=15)

Group		GT	Verbal Cue Recognition (VCR)
1	Mean	99.07*	10.60
	SD	14.31	2.16
2	Mean	100.20	10.60
	SD	15.17	2.67
3	Mean	98.60	11.00
	SD	13.92	2.59
		$F(2, 41) < 1, p > .05$	$F(2, 42) < 1, p > .05$

*GT missing for one soldier.

Data Collection Instruments

Verbal Cue Recognition (VCR) Test.[1] The VCR Test was administered to determine whether military vocabulary deficiencies might contribute significantly to lower R&I performance. During the test the soldier was presented with line drawings, one at a time, of 15 vehicles from the Basic CVI program. On each vehicle five parts or attachments were enclosed in a shaded and numbered rectangle. Below the drawing were numbers 1 to 5. An audio tape was played on which an instructor enunciated the name of one of the parts in the rectangle such as bore evacuator, muzzle break, sagger, etc. The soldier was required to circle the number below the figure that corresponded to the part. The names were taken from the script used in the Basic CVI Training Program.

Basic Combat Vehicle Identification (CVI) Program. The CVI program consists of 35mm slide images of 1/85 scale models placed in the same location on a terrain board in order to standardize background cues. The complete program has six training modules of five vehicles each for a total of 30 vehicles. The modules are comprised of both threat and friendly vehicles. In research by Smith et al., 1980, soldier identification performances were compared among the individual modules and no differences were found. This

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[1]The VCR Test was designed for research into the effects on CVI performance of military vocabulary deficiencies (See Shope et al., 1986). A split-half correlation of r (n = 78) = .68, p <.01, found in the current data provides a comparable measure of reliability reported by Shope [r (n = 129) = .67, p <.0001)].

permitted a generalization about performance on one module to other modules or CVI skills overall. Each module is divided into two training sections and a test section. Five views are shown (front, two oblique and two sides), one at a time, of each vehicle in each training section. An instructor reads from a prepared manual the significant identifying cues for each vehicle. Soldiers make a written response to each image, F (friend) or T (threat) and the name or number of the vehicle. In section one, the instructor sets the presentation pace based on soldier participation. In section two, presentation time is 15 seconds and in section three, the module test, 8 seconds. Depending on the number of questions asked during training, on the average, about 25 minutes are required to complete one module; following a two module block of training a 10 minute break is given. After completion of the six modules, a test composed of 2 views (a front and oblique) of each of the 30 vehicles is given.

In this research, the final test module consisted of three views of each vehicle--a right oblique, left oblique and a front--as opposed to two views, an oblique and front, found in the standard Army program discussed above.[1] The additional oblique view was added based on research findings by Smith et al., 1980, that the front view was significantly more difficult to identify than the oblique or side views. It was recommended in that research that another view should be added to the final test in order to obtain a better performance estimate. A score was computed based on the number of slides correctly identified.

Procedure

Each of the three experimental groups was first given the VCR test followed by a series of R&I training and test sessions. One group received repeated training and testing on Module 1 and 2 from the Basic CVI program (10 vehicles) per training session. A second group received similar training and testing on Modules 1, 2 and 3 of the Basic CVI Program (15 vehicles) per training session. The final group received training and testing on Modules 1, 2, 3 and 6 of the Basic CVI Program (20 vehicles) per training session. No feedback was given at any time.

Table 2

Time Required to Train and Test Each Vehicle Group (in minutes)

Group	Number of Training Sessions 1	2	3	4	5	6
10 vehicles	50	100	150	200	250	300
15 vehicles	75	150	225	300	375	450
20 vehicles	100	200	300	400	-	-

[1]For a detailed description of the CVI program and the instructions used for training, see Instructor's Manual for GTA 17-2-9.

Table 2 shows the amount of time required to train and test each group. In the time allotted for the training and testing, it was possible to give six repetitions to the 10 and 15 vehicle groups but only four repetitions to the 20 vehicle group.

The three groups received training and testing concurrently at separate locations. Training took place within the period 0730 to 1130 on each of three days. Soldiers were assigned to seats and asked to occupy the same seat throughout the training. For each group, testing occurred immediately after a training repetition using a test module composed of vehicles appropriate to that group.

Equipment

Standard military issue 35mm Kodak carousel slide projectors were used. Zoom lens replaced the usual standard lens. The screen consisted of a 2'x3' piece of poster board securely attached to a speakers lectern. The correct image size was obtained by manipulating the zoom lens until the sizing slide image matched the template which was held against the screen.

Data Analysis

Analyses are based on pre and posttraining test performance scores derived from the number of slides identified correctly. Analysis of Variance (ANOVA), Chi Square, and the Duncan Multiple Range Test were the primary statistical tests used with supporting means, standard deviations and frequencies.

RESULTS

Results presented in this report address two issues: a) how performance across multiple training sessions changes as a function of whether groups are trained on 10, 15 or 20 vehicles in each training session; and b) whether performance is improved similarly for all soldiers by repeated training sessions or whether other factors should be considered.

Repeated Training with Different Numbers of Vehicles

In order to compare the effects of repeated training on performance with different numbers of vehicles, the number of slides correctly identified on each test from the pretraining test (T_0) through the fourth repetition of training and testing (T_4) were analyzed. Although groups with 10 and 15 vehicles received six training trials and tests, only the first four of the six from those two groups are being used for some analyses in order to maintain comparability with the 20 vehicle group which received only four. To assure that conclusions drawn were not influenced by confounding due to differences in ability and R&I specific knowledge, 15 soldiers in each group were matched on GT and VCR. An analysis of scores was first conducted using only data for the common 10 vehicles on which each group was trained. These data were subjected to an analysis of variance (ANOVA) involving soldiers, groups and tests. The ANOVA indicated significant performance differences among groups across training sessions and tests [$F(8, 168) = 2.57$, $p < .02$]. Supporting this analysis, means and standard deviations for each group on each test (T_0-T_4) of the number of vehicles identified are presented in Table 3. To further evaluate these findings, means of groups at each test T_0 through T_4 were analyzed by a Duncan Multiple Range Test. The results show that when comparing only the common 10 vehicles in each of the three groups, the performance improvement with successive training periods is greater for soldiers trained on 10 vehicles per training session; soldiers in the 15 and 20 vehicle per training session groups generally show comparable but slower performance improvements. However, it must be remembered that the performance in groups 15 and 20 on the 10 common vehicles is complicated by the additional vehicles in their respective groups that increase the task difficulty and thus, a reduction in their mean performance on the 10 common vehicles could be expected. Based on Table 3, it appears that groups 15 and 20 show no significant differences on T_3 and T_4. This suggests that the effect on performance of adding either 5 or 10 vehicles is essentially the same.[4] Finally, the differing amounts of time required to reach the various performance levels by the three groups must be kept in mind. In Figure 1 the mean number of slides identified by each group is shown as a function of the time required to achieve that level at each of the four training and test sessions (maximum score possible is 30).

As noted above, evaluating the effects of repeated training with different numbers of vehicles is most appropriate when comparable data for each group is used. However, the conclusions reached through that analysis are generalizable to the extent we can infer the representativeness of those common 10

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[4]This is possible with the Basic CVI program because modules were initially balanced to be equally difficult.

Table 3

Means and Standard Deviations of Number of Slides Correctly Identified for the Common 10 Vehicles Using Matched Samples of 15 Soldiers in Each Group (V_{10}, V_{15}, V_{20})[1]

Test (T_t)[2,3]		Group V_{10}	Group V_{15}	Group V_{20}
T_0	M	.27 a* d	.93 a d	1.27 a d
	SD	1.03	1.79	1.58
T_1	M	13.67 a e	11.27 ab e	8.53 b e
	SD	10.22	7.94	5.69
T_2	M	16.87 a e	13.00 b e	15.93 ab f
	SD	10.08	8.57	5.38
T_3	M	22.93 a f	19.20 b f	17.60 b fg
	SD	7.99	8.28	5.74
T_4	M	25.27 a f	19.13 b f	20.20 b g
	SD	5.65	8.00	5.97

*Total possible score = 30 slides

[1]For Group, V_{10} refers to group trained on 10 vehicles per training session; V_{15} and V_{20} are similarily defined.

[2]T_t refers to the test taken following the t^{th} training session; T_0 is the pretest.

[3]Duncan Multiple Range Tests were performed to compare differences among groups at each test and across tests for a single group. Letters immediately following the means indicate the significance of differences between groups; letters on the next line compare differences across tests. Different letters indicate significant differences among column (group) and row (test) means, respectively ($p = .05$).

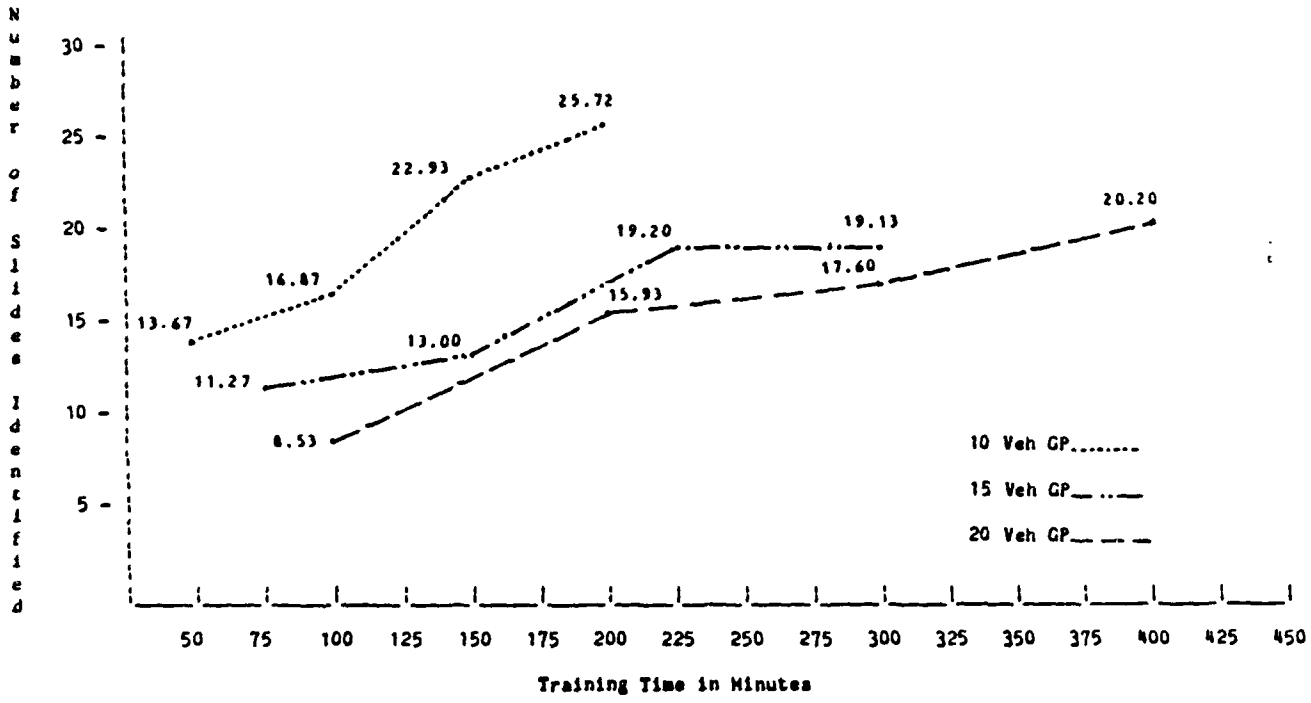

Figure 1. Mean Number of Slides Identified by Groups Trained on 10, 15, or 20 Vehicles at Each Test (T_1 - T_4) Based on Performance to Common 10 Vehicles for Matched Samples (n = 15)

vehicles. One way of addressing this issue is to compare the changes in identification performance curves for groups over test periods using data based on the common 10 vehicles and for the total number of vehicles trained. Since soldiers differed in each group on the possible correct number of slides, all scores were converted to proportions. An analysis of variance of these data over test periods T_0 through T_4 for soldiers trained on 10, 15, and 20 vehicles indicated that there were significant differences among the performance curves over test periods [$F(4,112) = 17.56$, $p = .0001$]. To interpret this finding, the means of each of these measures for each group in test sessions T_0 through T_6 were analyzed by a Duncan Multiple Range Test (See Table 4).

Based on that analysis, regardless of what measure (the common 10 or all vehicles trained) was used, no significant differences exist after the second training period ($p > .05$). Thus it would appear that use of a performance measure based on the common 10 vehicles provides a reasonably good estimate of near asymptotic performance for all groups but not for the entire course of learning.

Which group will provide the most learning in the shortest time? In Table 4 the means and proportions of slides identified by each group at each test are shown. Examination of T_4 suggests that the 20 vehicle groups did best at 41.40 slides, the 15 vehicle group next at 29.25 slides and the 10 vehicle group the poorest at 25.27 slides. However, if the amount of time to train to the various levels is taken into account, a different pattern emerges. In Figure 2, the mean proportion of slides identified correctly by each group using the 10, 15, and 20 vehicles is plotted against training time.

When training time is held constant for all three groups the greatest amount of learning per hour of instruction occurs with the 20 vehicle group as illustrated in Table 5. In 200 minutes the 20 vehicle group learned 9 slides per hour followed by the 15 vehicle group (7.7 slides per hour) followed by the 10 vehicle group (7.6 slides per hour). Similar findings are illustrated in Table 6 for 300 minutes of instruction.

Table 4

Means and Standard Deviations of Response Frequencies (F) and Proportions (P) for Identification (Slides) Performance for Matched Samples (Gps 2-3)[1]

After T_t Training Periods		Gp 1 (n=15) 10 Vehicles 30 Slides	Gp 2 (n=15) 15 Vehicles 45 Slides		Gp 3 (n=15) 20 Vehicles 60 Slides	
		Common 10	Common 10	All Veh Trained	Common 10	All Veh Trained
T_o	$\bar{F}$	.27	.13	1.27	1.27	2.07
	S_f	1.03	1.79	2.15	1.58	2.89
			a	a	a	a
	$\bar{p}$	.01	.03	.03	.04	.03
	S_p	.03	.06	.05	.05	.05
T_1	$\bar{F}$	13.67	11.27	17.55	8.53	21.00
	S_f	10.22	7.94	11.84	5.69	10.75
			b	b	c	d
	$\bar{p}$	.46	.38	.39	.28	.35
	S_p	.34	.26	.26	.19	.18
T_2	$\bar{F}$	16.87	13.00	22.95	15.93	29.87
	S_f	10.08	8.57	12.05	5.38	11.43
			e	fg	f	g
	$\bar{p}$	.56	.43	.51	.53	.50
	S_p	.34	.29	.27	.18	.19
T_3	$\bar{F}$	22.93	19.20	28.80	17.60	35.40
	S_f	7.99	8.28	12.17	5.74	11.04
			h	h	i	i
	$\bar{p}$	.76	.64	.64	.59	.59
	S_p	.27	.28	.27	.19	.18
T_4	$\bar{F}$	25.27	19.13	29.25	20.20	41.40
	S_f	5.65	8.00	12.00	5.97	11.03
			h	h	jk	k
	$\bar{p}$	.84	.64	.65	.67	.69
	S_p	.19	.27	.27	.20	.18
T_5	$\bar{F}$	25.93	22.60	35.00		
	S_f	4.85	7.39	9.62		
	$\bar{p}$	.86	.75	.78		
	S_p	.16	.25	.21		
T_6	$\bar{F}$	27.80	23.47	35.67		
	S_f	2.98	8.51	11.80		
	$\bar{p}$	.93	.78	.79		
	S_p	.10	.28	.26		

[1] A Duncan Multiple Range Test was performed to compare differences among tabled means for groups 2 and 3, and training periods T_o through T_4 (p=.05). Data for T_5 and T_6 were not included in this test but show very small differences between measures as do results for T_3 and T_4.

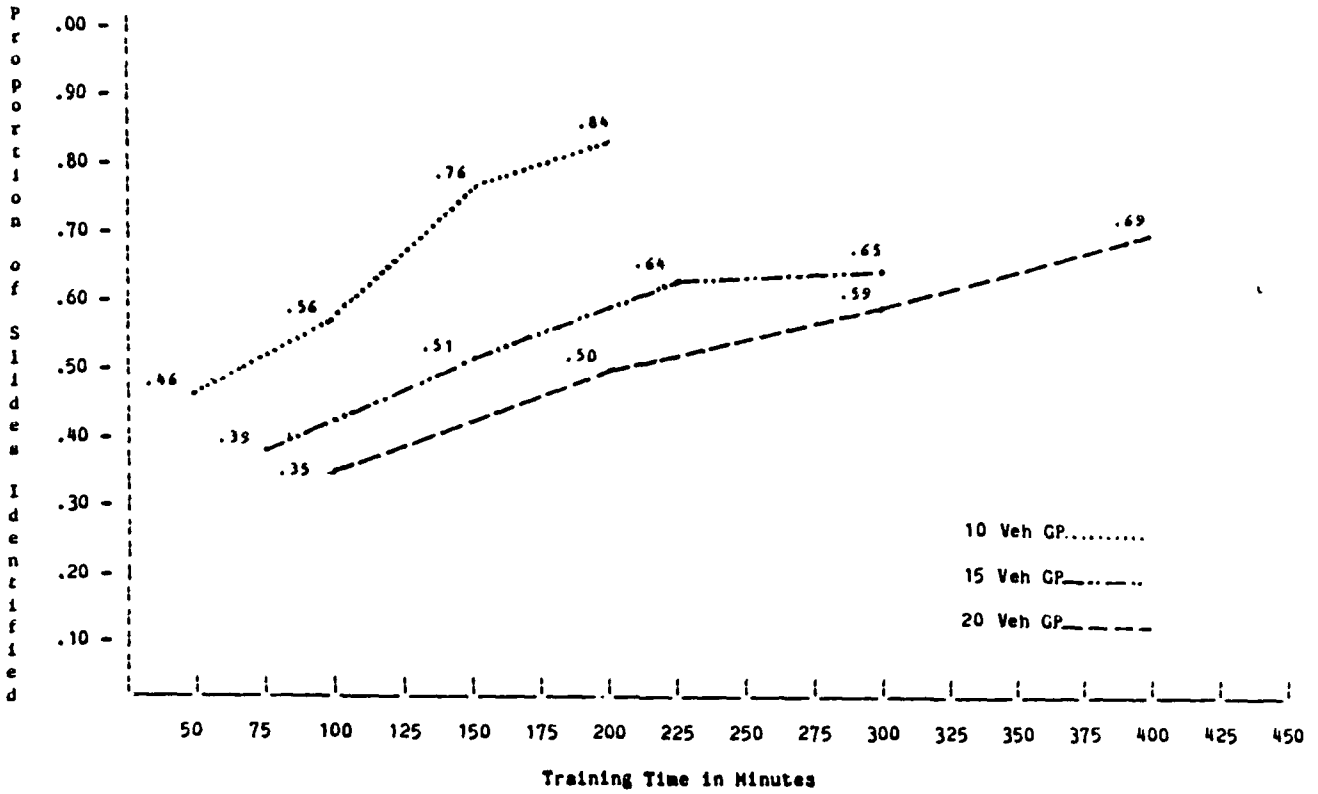

Figure 2. Mean Proportion of Slides Identified by Groups Trained on 10, 15, or 20 Vehicles at Each Test (T_1 - T4) Based on Performance for Matched Samples ($\underline{n}$ = 15)

The question of what number of vehicles (e.g., 10, 15, 20) or what number of modules (e.g., 2, 3, 4) taught per training session will provide the most efficient learning for the time invested cannot be answered directly from the research. However, some estimates can be made. In Table 7 we see that if the performance on a second group of 10 different vehicles can be presumed to be similar to the initial 10, then in the 400 minutes 50.4 slides would be identified compared with 41.4 slides for the group trained on 20 vehicles from the outset. The data in Table 8 leads us to hypothesize that if 20 vehicles were to be learned in 200 minutes, it would be more efficient to teach two 50 minute sessions of vehicles 1-10 followed by two 50 minute sessions of vehicles 11-20, rather than two 100 minute sessions of vehicles 1-20 (33.74 slides identified versus 29.87). When 300 minutes total training time is allocated the same pattern occurs.

The above discussion of Table 7 and 8 does not, however, address the possible influence of other factors which effect the learning process. For example, memory loss or decay would be expected to take place with the 1-10 Vehicles between training groups 1-10 and 11-21, and during the period of time devoted to training on Vehicles 11-20. Also, the possibility exists that the similarity between some vehicles in the 1-10 group and the 11-20 group could interfere with the learning of vehicles in the second (11-20) group.

The consideration of retention of learned material should be addressed in the context of overlearning. Training on 10 vehicles at a time allows for overlearning because soldiers learn faster and there is time for more repetitions close together. Does this overlearning help reduce interference when more vehicles are added and aid retention when the increased number of vehicles are tested? Further research is needed to answer these questions.

Table 5.

Mean Number of Slides Identified by Each Group After 200 Minutes of Instruction

Grp	Vehicles Taught	No. of Slides	No. of Sessions	No. of Slides Identified	% of Slides Identified	No. of Slides Learned per hour of Instruction
1	10 veh.	30	4	25.27	84%	7.6
2	15 veh.	45	3	*25.60	57%	7.7
3	20 veh.	60	2	30.00	50%	9.0

* 28.8 slides identified in 225 minutes. Extrapolated to 25.60 for 200 minutes.

Table 6

Mean Number of Slides Identified by Each Group After 300 Minutes of Instruction

Grp	Vehicles Taught	No. of Slides	No. of Sessions	No. of Slides Identified	% of Slides Identified	No. of Slides Learned per hour of Instruction
1	10 veh.	30	6	27.80	93%	5.6
2	15 veh.	45	4	29.25	65%	5.9
3	20 veh.	60	3	35.40	59%	7.1

Table 7

Theoretical Comparison of Efficiency of Learning 20 Vehicles in Two Groups of 10 Versus One Group of 20. Total Training Time of 400 Minutes

Vehicles 1-10	Vehicles 11-20
4 50 Minute Sessions (200 minutes)	4 50 Minute Sessions (200 minutes)
$\bar{X}$ Slides Identified = 25.27	$\bar{X}$ Slides Identified = 25.27

Total Slides Identified in 400 minutes: 25.27 + 25.27 = 50.4 of 60 possible.

Vehicles 1-20

4 100 Minute Sessions (400 minutes)

Total Slides Identified in 400 minutes = 41.40 of 60 possible

Table 8

Theoretical Comparison of Efficiency of Learning 20 Vehicles in Two Groups of 10 Versus One Group of 20. Total Training Time of 200 Minutes

Vehicles 1-10	Vehicles 11-20
2 50 Minute Sessions (100 minutes)	2 50 Minute Sessions (100 minutes)
$\bar{X}$ Slides Identified = 16.87	$\bar{X}$ Slides Identified = 16.87

Total Slides Identified in 400 minutes: 16.87 + 16.87 = 33.74 of 60 possible.

Vehicles 1-20

2 100 Minute Sessions (200 minutes)

Total Slides Identified in 200 minutes = 29.87 of 60 possible

An additional consideration, that of retention of learned material, should be addressed in the context of overlearning. Training on 10 vehicles at a time allows for overlearning because soldiers learn faster and there is time for more repetitions. Does this overlearning help reduce interference when more vehicles are added and aid retention when the increased number of vehicles are tested? Further research is needed to answer these questions.

"High" Achievers vs "Low" Achievers

It is apparent from results already presented that the R&I task is difficult. Facing this fact and accepting the importance of R&I to successful distruction of enemy, not friendly, vehicles, it is relevant to ask whether repeated training alone can bring all soldiers to reasonable performance levels in a timely manner. In order to address this question, identification performance data were examined for each of the 78 individual soldiers who completed the initial training to determine whether some soldiers might find the R&I task easier than others. Such soldiers could be characterized as "high" achievers. For these soldiers repeated training might prove more cost-effective. In order to address this matter, it was reasoned that it might be possible to make a judgement about soldiers' propensity for acquiring R&I knowledge based on the results of one training session.

The performance curves on subsequent training sessions were examined for soldiers classified as "poor" or "good" in the first training session. Empirically, the classification was accomplished in three different ways: a) by a criterion based on the number of slides correctly identified on the first test following initial training; b) by dividing the sample roughly in half; and c) by dividing the sample again into the upper two-thirds and the lower one-third. Figures 3-5 illustrate the application of these measures.

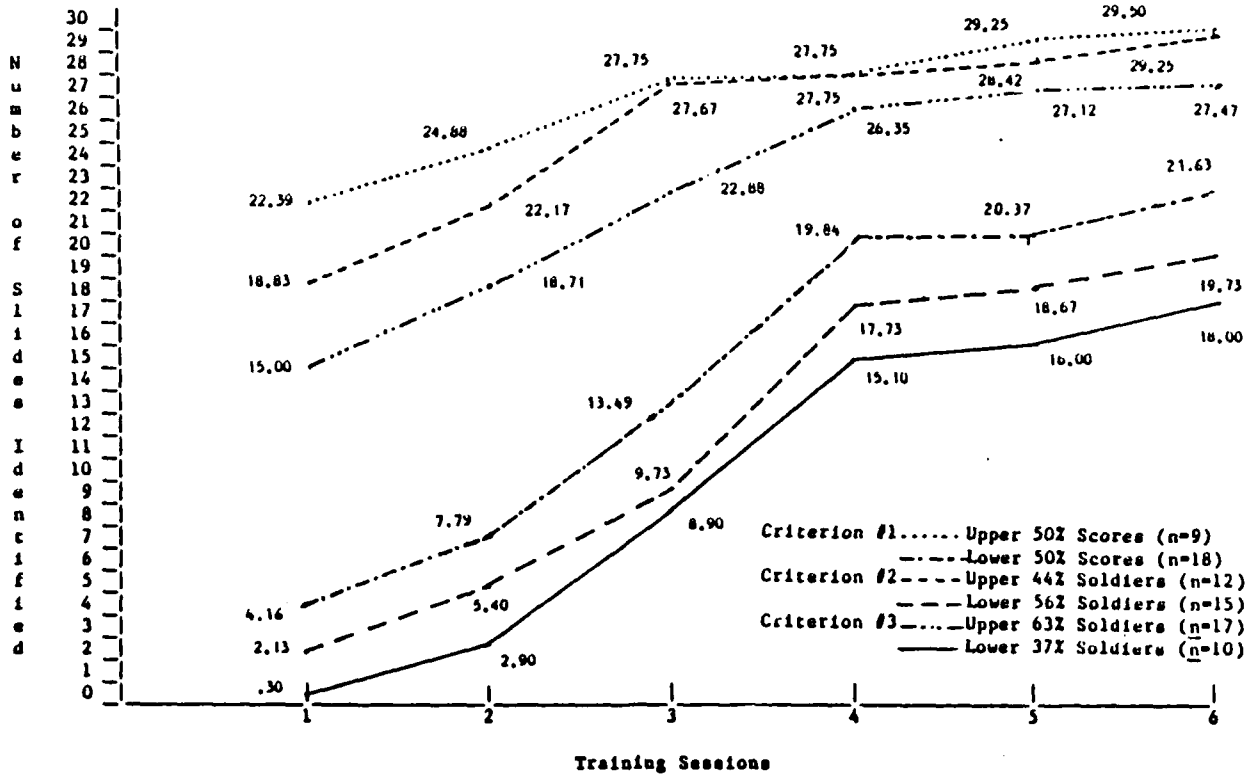

Figure 3. Mean Number of Slides Identifed for High and Low Achieving Soldiers Trained on 10 Vehicles Per Training Session Using Three Classification Criteria

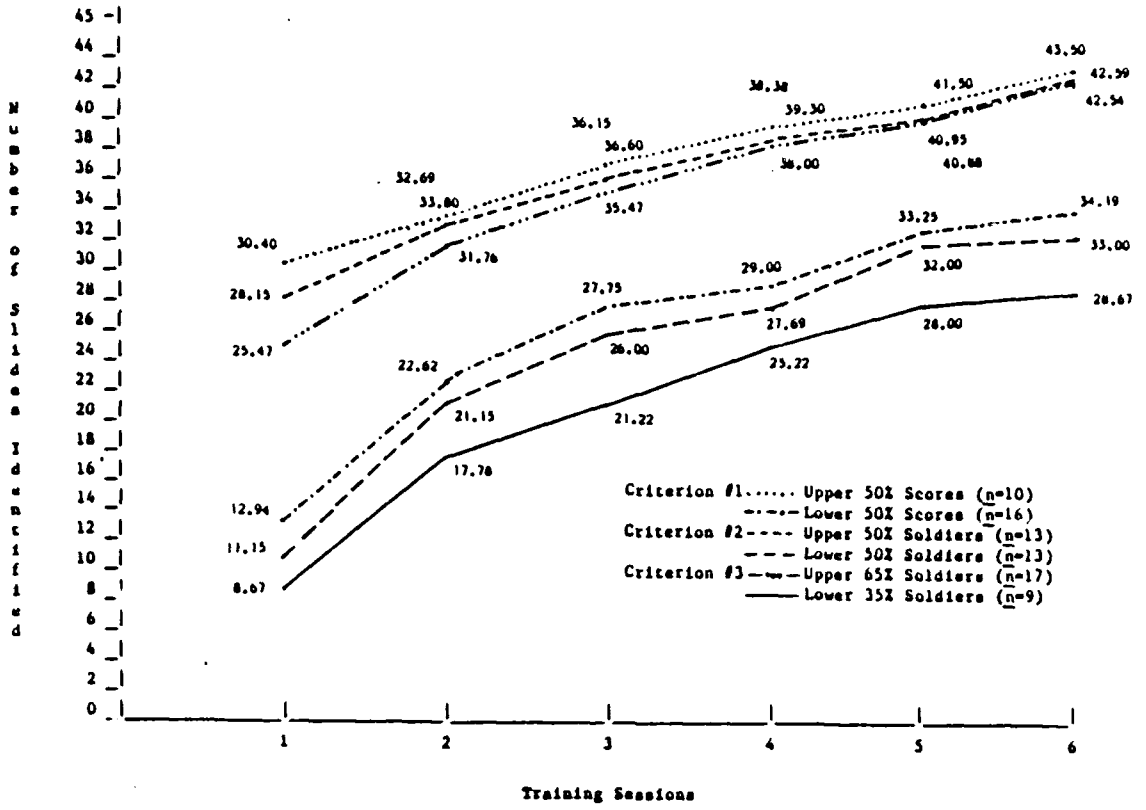

Figure 4. Mean Number of Slides Identified for High and Low Achieving Soldiers Trained on 15 Vehicles Per Training Session Using Three Classification Criteria

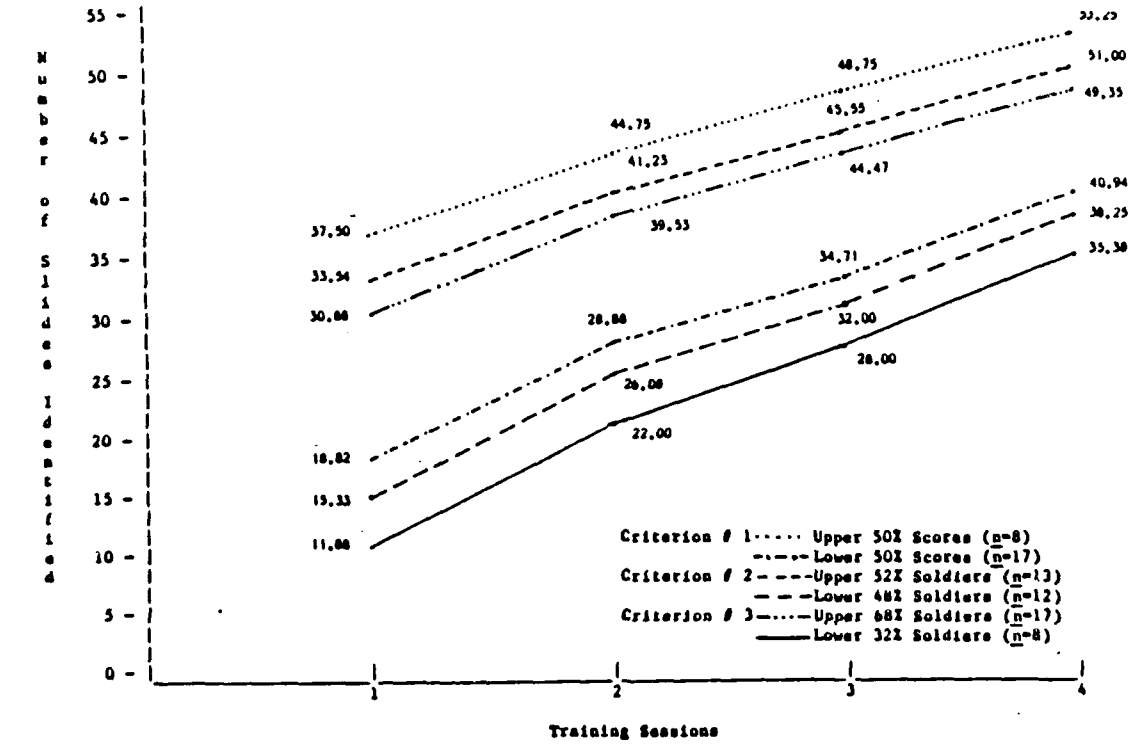

Figure 5. Mean Number of Slides Identified for High and Low Achieving Soldiers Trained on 20 Vehicles Per Training Session Using Three Classification Criteria

In each figure, criterion 1 is a division of the sample into scores of 15 or greater and less than 15, criterion 2 roughly divides the total sample of soldiers into equal halves and criterion 3 which divides the sample roughly into the upper 67% and lower 33%. While the exact relationship between "high" achievers and "low" achievers does differ depending on the classification criterion used, examining these performance curves for all three groups generally support the conclusion that soldiers classed as "low" achievers will require at least four training sessions to attain a performance level the "high" achievers reach after one training session. Tables presented in Appendix A indicate these performance differences for several possible criteria that might be used for defining achievement category. While results in these tables are based on relatively few cases, they do indicate the performance levels that might be attained after repeated training of only the more capable soldiers. Furthermore, these findings might be useful in selecting those who would benefit most from repeated CVI training in contrast to those who might be selected to perform other unit functions not requiring CVI skills.

DISCUSSION AND CONCLUSIONS

Discussion

How Much Training do Soldiers Need?

During the development and testing of the TAATS training programs, preliminary assessments of soldiers' recognition and identification skills were made before training was conducted. The findings from these research efforts showed that the average pre-CVI training scores for identification was one vehicle out of 30. After one complete training cycle, i.e., 6 one-hour training periods in which 30 vehicles were covered, the performance increased significantly to 9 vehicles identified with a standard deviation of 18. Two important conclusions were drawn from these consistent findings. The first conclusion was that the R&I task is difficult, and for the material to be learned, the amount of training time and frequency of training had to be more clearly defined. The second conclusion, based on the large standard deviation, was that it was necessary to more closely examine the idea that all soldiers should receive R&I training.

The primary thrust of this research effort was to explore how R&I performance changes with massed training sessions, when soldiers are exposed to training involving 10, 15, or 20 vehicles per training session. Using common identification performance data for matched groups of soldiers, results are consistent with the body of knowledge in learning research which holds that as the complexity of the learning task increases, the rate of learning decreases. Indeed, 10 vehicles per session led to more rapid learning than did 15 or 20 per session. Given that a smaller number of vehicles per session is more efficient, the question remains of how much efficiency is gained by using a smaller number of vehicles, 10 for example, in speed of initial learning and in subsequent retention over use of larger numbers (15 or 20)? Further research is needed to answer this question.

Affordability Considerations of R&I Training

The Problem. After four massed training sessions on 15 vehicles (300 minutes training time) or 20 vehicles (400 minutes training time) and using performance data from all soldiers in Group 2 and Group 3, the number of correct slide identifications reached only 65% and 69% respectively. The question naturally arises concerning the affordability of R&I training for everyone. Further augmenting this concern is the fact that knowledge acquired appears somewhat transient--it decays over time (Heuckeroth et al., 1986). Given these facts, at least two questions need to be addressed.

First, how important is it for soldiers to be able to recognize and identify friendly and enemy vehicles? In answering this question the focus is on materiel resources and people. If a soldier incorrectly fires on one of his own vehicles, the loss of equipment (not to mention the costs inherent in the loss of lives) may be in the millions; if he fails to correctly identify an enemy, he and his weapon may become the casualty with a corresponding loss. Because the projected threat-to-friend force ratio is expected to be quite large (6:1), NATO units can ill afford to lose equipment or soldiers which will

result in further increasing the ratio. Apart from cost of equipment lost due to inadequate R&I skills, many of our soldiers will be killed. From the perspective of our cultural emphasis on the value of life, adequate CVI training is particularly relevant.

Second, given the importance of R&I to preservation of life, materiel resources and ultimately the winning of battles, how can these skills (or functions) be best provided? The Combat Vehicle Identification (CVI) Training programs developed and evaluated by the Fort Hood Field Unit and its contractors over the past several years came out of a concerted effort to employ the best available methodology for developing and evaluating training programs that will meet today's needs for R&I training throughout the Army. The apparent demonstrated difficulty of acquiring and retaining these R&I skills should stimulate further research. Electronic Identification Friend/Foe (IFF) has been widely discussed in the R&I community as a means to help resolve this problem. However, movement from the conceptual stage to developmental and implementation phases has been slow. The Army has been unable to wait for advanced technology to resolve the R&I problem. Given the need and the difficulty of acquisition and retention, the Target Acquisition and Analysis Training System (TAATS) program has sought to explore how to optimize acquisition (and retention) of R&I skills with the programs currently in the Army inventory. The current research supports the value of retraining which leads to higher levels of demonstrated R&I skills.

Toward a Solution. Given the apparent problem in acquiring and retaining R&I skills and the importance of these skills to success on the modern battlefield, it seemed relevant to ask about the importance of individual soldier capability differences. Large standard deviations of performance indicated a large amount of individual performance variability. This in turn prompted a closer look at the performance of individual soldiers who had received repeated training. Examination of scatterplots of identification performance following the first training session and subsequent sessions seemed to indicate that soldiers who performed relatively poorly after the first session, tended to show slower performance increases with subsequent training. These initial impressions led to more definitive analyses in which soldier performance following the first training session served as a basis for categorizing them as "low" or "high" achievers. Using several categorization criteria, the performance curves of these achievement groups with repeated training were plotted. While different criteria did lead to absolute differences in performance curves, inspection of those curves for most criteria generally indicated that "low" achievers take about four training sessions to attain a performance level attained by "high" achievers following one such session. Figures are presented in the text (RESULTS) for three of these criteria. Application of many other criteria are tabled in Appendix A. While data presented in these tables are based on a relatively small number of cases, their consistency from criterion to criterion tends to lend credence to their relative validity. A trainer who knows the number of vehicles to be trained can estimate the expected performance proficiency of soldiers following subsequent training given only their first posttraining test performance. With these data, the trainer may decide that some soldiers can be better utilized if assigned to duties which do not require R&I proficiency. Admittedly, these results do not anwer the question about who should receive repeated R&I training. These results do,

however, provide the trainer with a methodology whereby he may make a more informed decision about how much training could be profitably provided to different soldiers in his unit.

The Army has limited training time available. Thus, it is important to indicate the level of commitment training and retraining required. Documentation describing the Basic CVI program (Smith et al., 1980) indicates training on one module takes an average of 25 minutes and a maximum of 50 minutes. Variation in time required is dependent largely on the number of questions or amount of discussion by soldiers in the "manual presentation phase" of the training. However, extensive research with this program indicates that for the first training session, 30 minutes per module is a good average. Hence, the complete first training cycle of the Basic CVI Program (GTA 17-2-9) consisting of six modules (30 vehicles) requires about three actual hours of training. Again, our research indicates that for the second training session fewer questions and less discussion makes 25 minutes per module a good average. For subsequent training sessions this time approaches 20 minutes per module. With these estimates then, actual training time for three complete cycles of six modules each is about 7.5 hours.

Appendix A provides a means of estimating how many training cycles using 2 (10 vehicles), 3 (15 vehicles) or 4 (20 vehicles) modules are required for "high" and "low" achievers to reach varying levels of performance. For example, in Table 3 of the Appendix A, the 1st criterion (noted in the far left column), the "high" group (84% of soldiers) given 4 cycles of 4 modules (5 hours training time) would attain 81% correct slide identification.

Conclusions

- Although additional research is required to conclusively establish the effects of overlearning on retention of this type of material, these findings tentatively suggest that training of no more than 10 different vehicles per training session is more effective than training that addresses more than 10 vehicles per session.

- Some soldiers have extreme difficulty learning to recognize and identify vehicles even after lengthy training. Consideration should be given to the use of a selective procedure, such as using scores following a single training session on the Basic CVI Training Program (GTA 17-2-9), to determine who should receive additional R&I training.

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APPENDIX A

Expected Performance of Low and High Achieving Soldiers Trained on 10, 15, or 20 Vehicles Per Training Session

Table 1

Mean Number of Slides Identified for Low and High Achieving Soldiers Trained on 10 Vehicles Per Training Session Using Different Criteria for Defining Achievers

Criterion	Achievement Category	Slides Identified Soldiers[2]	Tests T_0	T_1	T_2	T_3	T_4	T_5	T_6
1	Low	LT 1 (0%)	0.00	0.00	2.14	5.71	12.86	13.86	14.43
		(N =7) (26%)	0%	0%	7%	19%	43%	46%	48%
	High	GE 1	.20	12.90	16.60	21.90	25.45	26.20	27.30
		(N = 20) (74%)	2%	43%	55%	73%	85%	87%	91%
2	Low	LT 2 (3%)	0.00	.30	2.90	8.90	15.10	16.00	18.00
		(N = 10) (37%)	0%	1%	10%	30%	50%	53%	60%
	High	GE 2	.24	15.00	18.71	22.88	26.35	27.12	27.47
		(N = 17((63%)	1%	50%	62%	76%	88%	90%	92%
3	Low	LT 5 (13%)	0.00	.92	4.00	9.08	16.00	16.92	18.33
		(N = 12) (44%)	0%	3%	13%	30%	53%	56%	61%
	High	GE 5	.27	16.47	19.93	24.60	27.13	27.87	28.47
		(N = 15) (56%)	1%	55%	66%	82%	90%	93%	95%
4	Low	LT 8 (23%)	0.00	2.13	5.40	9.73	17.73	18.67	19.73
		(N = 15) (56%)	0%	7%	18%	32%	59%	62%	66%
	High	GE 8	.33	18.83	22.17	27.67	27.75	28.42	29.29
		(N = 12) (44%)	1%	63%	74%	92%	93%	95%	98%
5	Low	LT 9 (27%)	0.00	2.50	5.31	10.69	18.12	18.69	20.19
		(N = 16) (59%)	0%	8%	18%	36%	60%	62%	67%
	High	GE 9	.36	19.82	23.82	29.91	28.09	29.27	29.46
		(N = 11) (41%)	1%	66%	79%	93%	94%	98%	98%
6	Low	LT 13 (40%)	0.00	3.06	6.24	11.65	18.71	19.29	20.65
		(N = 17) (63%)	0%	10%	21%	39%	62%	64%	69%
	High	GE 13	.40	20.60	24.10	28.00	28.10	29.30	29.60
		(N = 10) (37%)	1%	69%	80%	93%	94%	98%	99%
7	Low	LT 14 (43%)	0.00	3.61	6.94	12.61	19.33	19.89	21.17
		(N = 18) (67%)	0%	12%	23%	42%	64%	66%	71%
	High	GE 14	.50	22.38	24.88	27.75	27.75	29.25	29.50
		(N = 9) (33%)	2%	75%	83%	93%	93%	98%	98%
8	Low	LT 15 (50%)	0.00	4.16	7.79	13.47	19.84	20.37	21.63
		(N = 19) (70%)	0%	13%	26%	45%	66%	68%	72%
	High	GE 15	.50	22.38	24.88	27.57	27.71	29.14	29.43
		(N = 8) (30%)	2%	75%	83%	92%	92%	97%	98%
9	Low	LT 19 (63%)	0.00	4.85	8.65	14.20	20.30	20.85	22.05
		(N = 20) (74%)	0%	16%	29%	47%	68%	70%	74%
	High	GE 19	.57	23.00	24.86	27.57	27.71	29.14	29.43
		(N = 7) (26%)	2%	77%	83%	92%	92%	97%	98%
10	Low	LT 20 (67%)	0.00	5.52	9.14	14.52	20.52	21.24	22.33
		(N = 21) (78%)	0%	18%	30%	30%	68%	71%	74%
	High	GE 20	.67	23.67	25.83	28.00	28.83	29.17	29.67
		(N = 6) (22%)	2%	79%	86%	93%	96%	97%	99%

[1] In all cases the criterion for defining achievement category was based on soldier performance following the first training session (T_1). Percentages are based on a total of 30 slides presented.

[2] LT and GE in this column means "less than" and "greater than or equal," respectively. With a maximum score of 30, "LT 1 (0%)" for the first tabled criterion means that for this way of defining "Low" achievers, the maximum possible score on the first posttest was 0—0/30 x 100 = 0%. Percentages following "(N = _)" entries are simply the percent of soldiers in the total sample who are in the "Low"/"High" category for this criterion

Table 2

Mean Number of Slides Identified for Low and High Achieving Soldiers Trained on 15 Vehicles Per Training Session Using Different Criteria for Defining Achievers

Criterion	Achievement Category	Slides Identified Soldiers[2]	Tests T_0	T_1	T_2	T_3	T_4	T_5	T_6
1	Low	LT 7 (13%)	.25	4.00	10.00	15.25	20.00	24.75	26.00
		(N =4) (15%)	1%	9%	22%	34%	44%	55%	58%
	High	GE 7	1.64	22.50	30.00	34.09	35.27	38.54	39.91
		(N = 22) (85%)	4%	50%	67%	76%	78%	86%	89%
2	Low	LT 13 (27%)	.14	7.29	14.57	19.00	22.57	25.71	28.43
		(N = 7) (27%)	1%	16%	32%	42%	50%	57%	63%
	High	GE 13	1.90	24.21	31.47	35.37	37.05	40.37	41.21
		(N = 19) (73%)	4%	54%	70%	79%	82%	90%	92%
3	Low	LT 15 (31%)	.44	8.67	17.78	21.22	25.22	28.00	28.67
		(N =9) (35%)	1%	19%	40%	47%	56%	62%	64%
	High	GE 15	1.94	25.47	31.76	35.47	38.00	40.88	42.59
		(N = 17) (65%)	4%	57%	71%	79%	84%	91%	95%
4	Low	LT 16 (33%)	.50	9.30	18.10	22.60	27.00	29.60	30.20
		(N = 10) (38%)	1%	20%	40%	50%	60%	66%	67%
	High	GE 16	2.00	26.12	32.44	35.00	38.19	40.69	42.50
		(N = 16) (62%)	4%	58%	72%	78%	85%	90%	94%
5	Low	LT 17 (36%)	.73	9.91	19.46	23.82	27.91	30.46	31.27
		(N = 11) (42%)	2%	22%	43%	52%	84%	68%	69%
	High	GE 17	1.93	26.80	32.40	34.87	38.33	40.80	42.53
		(N = 15) (58%)	4%	60%	72%	77%	85%	91%	95%
6	Low	LT 18 (38%)	.67	10.50	21.00	25.42	29.08	31.58	32.33
		(N = 12) (46%)	2%	23%	47%	56%	65%	70%	73%
	High	GE 18	2.07	27.50	32.00	34.36	38.00	40.57	42.43
		(N = 14) (54%)	5%	61%	71%	76%	84%	90%	94%
7	Low	LT 20 (42%)	.62	11.15	21.15	26.00	27.69	32.00	33.00
		(N = 13) (50%)	1%	25%	47%	58%	62%	71%	73%
	High	GE 20	2.23	28.15	32.69	36.15	38.38	40.85	42.69
		(N = 13) (50%)	5%	63%	73%	80%	85%	91%	95%
8	Low	LT 21 (44%)	.71	11.79	21.71	26.50	28.14	32.43	33.32
		(N = 14) (54%)	2%	26%	48%	59%	63 %	72%	74%
	High	GE 21	2.25	28.83	33.00	36.33	38.83	41.08	42.92
		(N = 12) (46%)	5%	64%	73%	81%	86%	91%	95%
9	Low	LT 22 (47%)	1.00	12.94	22.62	27.75	29.00	33.25	34.19
		(N = 16) (62%)	2%	29%	50%	62%	64%	74%	76%
	High	GE 22	2.10	30.40	33.80	36.60	39.30	41.50	43.50
		(N = 10) (38%)	5%	68%	75%	81%	87%	92%	97%
10	Low	LT 23 (49%)	.94	13.47	22.82	28.29	29.59	33.94	34.71
		(N = 17) (65%)	2%	30%	51%	63%	66%	75%	77%
	High	GE 23	2.33	31.33	31.67	33.56	36.33	41.11	43.56
		(N = 9) (35%)	5%	40%	70%	75%	81%	91%	97%

[1]In all cases the criterion for defining achievement category was based on soldier performance following the first training session (T_1). Percentages are based on a total of 45 slides presented.

[2]LT and GE in this column means "less than" and "greater than or equal," respectively. With a maximum score of 45, "LT 7 (13%)" for the first tabled criterion means that for this way of defining "Low" achievers, the maximum possible score on the first posttest was 6—6/45 x 100 = 13%. Percentages following "(N = _)" entries are simply the percent of soldiers in the total sample who are in the "Low"/"High" category for this criterion.

Table 3

Mean Number of Slides Identified for Low and High Achieving Soldiers Trained on 20 Vehicles per Training Session Using Different Criteria for Defining Achievers[1]

Criterion	Achievement Category	Slides Identified Soldiers[2]	Tests T_0	T_1	T_2	T_3	T_4
1	Low	LT 12 (18%)	.50	8.00	16.75	20.50	26.75
		(N =4) (16%)	1%	13%	28%	34%	45%
	High	GE 12	2.71	28.00	37.24	42.76	48.33
		(N = 21) (84%)	5%	47%	62%	71%	81%
2	Low	LT 13 (20%)	.40	8.80	18.80	23.80	31.40
		(N = 5) (25%)	1%	15%	31%	40%	52%
	High	GE 13	2.85	28.80	37.75	43.05	48.25
		(N = 20) (75%)	5%	48%	63%	72%	80%
3	Low	LT 18 (28%)	.38	11.88	22.00	28.00	35.38
		(N = 8) (32%)	1%	20%	37%	47%	59%
	High	GE 18	3.29	30.88	39.59	44.47	49.35
		(N = 17) (68%)	6%	52%	66%	74%	82%
4	Low	LT 19 (30%)	.44	12.56	23.22	29.00	35.44
		(N = 9) (36%)	1%	21%	39%	48%	59%
	High	GE 19	3.44	31.69	40.00	44.94	50.19
		(N = 16) (64%)	6%	58%	67%	75%	84%
5	Low	LT 23 (38%)	.40	13.50	24.00	29.90	36.30
		(N = 10) (40%)	1%	23%	40%	50%	61%
	High	GE 23	3.67	32.33	40.60	45.40	50.60
		(N = 15) (60%)	6%	54%	68%	76%	84%
6	Low	LT 25 (42%)	.36	14.46	25.00	30.91	37.27
		(N = 11) (48%)	1%	24%	42%	52%	62%
	High	GE 25	3.93	32.93	41.00	45.71	50.86
		(N = 14) (54%)	7%	55%	68%	76%	85%
7	Low	LT 26 (43%)	.75	15.33	26.08	32.00	38.25
		(N = 12)(48%)	1%	26%	43%	53%	64%
	High	GE 26	3.85	33.54	41.23	45.85	51.00
		(N = 13) (52%)	6%	56%	69%	76%	85%
8	Low	LT 27 (43%)	.92	16.15	27.31	32.85	38.77
		(N = 13) (52%)	2%	27%	46%	55%	65%
	High	GE 27	3.92	34.17	41.17	46.08	51.50
		(N = 12) (48%)	7%	57%	69%	77%	86%
9	Low	LT 28 (45%)	1.38	18.19	28.50	34.44	40.31
		(N = 16) (64%)	2%	30%	48%	57%	67%
	High	GE 28	4.11	36.56	43.67	47.67	53.00
		(N = 9) (36%)	7%	61%	73%	79%	88%
10	Low	LT 30 (48%)	1.35	18.82	28.88	34.71	40.94
		(N = 17) (68%)	2%	31%	48%	58%	68%
	High	GE 30	4.50	37.50	44.75	48.75	53.25
		(N = 8) (32%)	8%	63%	75%	81%	89%

[1]In all cases the criterion for defining achievement category was based on soldier performance following the first training session (T_1). Percentages are based on a total of 60 slides presented.

[2]LT and GE in this column means "less than" and "greater than or equal," respectively. With a maximum score of 60, "LT 12 (18%)" for the first tabled criterion means that for this way of defining "Low" achievers, the maximum possible score on the first posttest was 11—11/60 x 100 = 18%. Percentages following "(N = _)" entries are simply the percent of soldiers in the total sample who are in the "Low"/"High" category for this criterion.